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away from the influence of the land, the northward range of certain species appears to end at the southern limits of the south-east trades; as in the Wandering Albatross (*Diomedea exulans*), Long-winged Petrel (*Pterodroma macroptera*), and White-chinned Petrel (*Procellaria aequinoctialis*). In the Northern Hemisphere, a corresponding restriction of range seemingly occurs in the Black-footed Albatross (*Diomedea nigripes*).

The behavior of the Shearwaters in the fog off the California coast, the existence of a definite waterway between the mainland and Hood Island, and the apparent influence of the trade-winds in limiting habitats, seem to justify the conclusion that migrating birds are guided by physical phenomena, and not by a mysterious sense of direction. In fine, the solution of the problem is not found in the marvelous.

It has been well said: "The day is passing when scientists seek to employ striking or extraordinary phenomena in the solutions of their problems; rather are they looking to that which appears insignificant and commonplace."

Care, California Academy of Sciences, San Francisco, Calif.

THE ABBREVIATED INNER PRIMARIES OF NESTLING WOODPECKERS

BY JAMES P. CHAPIN

Plate XIX

WHILE examining nestlings of Woodpeckers, some years ago, belonging to the African genera *Chrysopicos*, *Campethera*, and *Dendropicos*, I noticed that the innermost primary of the first or "juvenal" set of remiges was always remarkably small and weak, (Fig.1) and thus utterly unlike its representative in the adult plumage. There, on the contrary, the first primary is nearly as long as the second and third, thus filling its place normally in the graded series of wing-quills. The young of another African wood-peck-

er, *Mesopicos goertae*, likewise showed reduction of the same¹ quill, but somewhat less in degree.

The term "juvenal" is here employed in the sense proposed by Dr. Dwight² as the name for the plumage immediately succeeding the natal down, or where there is no such down, as in the Picidae, for the first plumage of the young bird.

In order to see this tiny feather, however, it is essential to have very young individuals, with the loerng primaries not yet com-

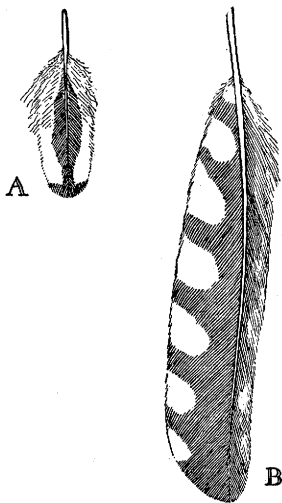


Fig. 1. *Dendropicos poecilolaemus*. First innermost primary in (A) juvenal and (B) adult plumage of female. $\times 1$.

pletely grown, for as soon as the latter have attained their full length the diminutive feather is at once molted, and its replacing quill comes in as large as that of adults. Thus a young wood-pecker which has already left the nest will seldom show the juvenal first primary. With the renewal of this first primary begins the post-juvenal molt of the remiges, so characteristic of young woodpeckers, ushering in the normal adult proportions of the wing.

So far as I am aware, no writer has yet called attention to this unique phenomenon, which cannot be exactly compared to the reduction of the first (outermost) secondary in the Phasianidae, since the feather there remains small throughout life, nor to the retarded development of the outer juvenal primaries in this same family and in *Opisthocomus*,¹ where they are not preceded by any small fore-

runners. Wondering whether this condition was of common occurrence among young Picidae, I next examined the nestlings of some of our common American species, and found that in the flickers a

¹ In this article the primaries will be numbered from the carpus outward.

² *Annals N. Y. Acad. Sci.*, XIII, 1900, p. 106.

³ See Pycraft, *History of Birds*, 1910, pp. 242-244.

still more unusual case presented itself, inasmuch as *two* inner primaries were shortened. The young Hairy and Downy Woodpeckers, likewise, had both the first and the second primaries dwarfed. Here again these reduced feathers are lost, and replaced by very much larger ones, at the outset of the post-juvenal molt.

In Mearns' Woodpecker and the White-headed Woodpecker both the first and the second primaries show similar arrested development in the juvenal plumage; but in the Red-bellied Woodpecker it is clear that the second is not affected, becoming at once full-sized, while the dwarfed first primary is shed at a very early date. The Haitian *Centurus striatus* resembles the Red-bellied; and the young Red-headed Woodpecker, similarly, has not more than one inner primary of reduced proportions. In the last-named species the post-juvenal molt, as Dr. Stone has pointed out,¹ is greatly retarded. So while the first primary is renewed at a time earlier perhaps than in other woodpeckers, all the remaining primaries are retained until about December. This is easily determined from the duller coloration of the juvenal quills.

To Mr. Outram Bangs I owe the opportunity of examining a nestling Ivory-billed Woodpecker, which I find to have the second primary markedly reduced, and the first apparently even more so. Still, the first juvenal feather has perhaps already been shed, and the young feather now wholly enclosed in its sheath may be a representative of the succeeding or "first winter" series. Young specimens of three South American species often referred to *Campephilus*, however, which are just renewing the first primary, show clearly that there is no reduction of the second quill—a surprising difference from the North American species. In a member of the Pileated group on the other hand, *Ceophlæus lineatus*, from Mexico, both the first and second primaries of the nestling's wing undergo reduction.

Among European woodpeckers, the Green Woodpecker and the Great Spotted Woodpecker were next examined, and both of them were found to have two inner primaries of dwarfed size in the juvenal set (Fig. 2). *Xiphidiopicus percussus* of Cuba and *Hypoxan-*

¹ Proc. Acad. Nat. Sci. Phila., 1896, p. 129.

thus rivolii of Ecuador have only one inner primary reduced, about as in *Chrysopicos*. In the U. S. National Museum there were specimens, sufficiently young, of two East Indian forms, *Tiga javanensis* and *Meiglyptes grammithorax*, which showed a single reduced primary, the first, in each case. That of *Meiglyptes* was decidedly small, but in *Tiga* the feather was of the same relatively large size as in *Mesopicos goertae*.

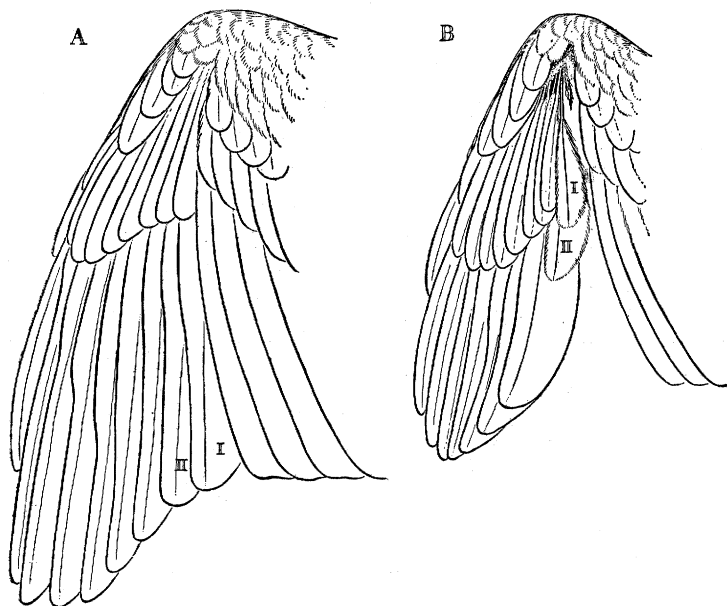


Fig. 2. *Picus viridis*. Wing of (A) adult; (B) Young, from above. $\times \frac{1}{2}$

By this time it was only natural that I should conclude the reduction of one or more inner primaries of the nestling to be a family character of the Picidae. The piculets, to be sure, might not exhibit it, for three rather young, though fully fledged, specimens of *Verreauxia africana* failed to show reduced wing feathers or even a subsequent post-juvenal molt. Yet they perhaps represent a family apart, more similar to the barbets than are the true woodpeckers.

Great was my surprise, consequently, on examining a nestling of the Yellow-bellied Sapsucker, Fig. 3. to find that none of the inner primaries, not even the first, was any smaller relatively than it would be in the adult. The same was true of the wings of fledglings in the Red-naped, Red-breasted, and Williamson's Sapsuckers; so the genus *Sphyrapicus*, as a whole, offers a notable exception to the general rule of reduction, or more accurately speaking,

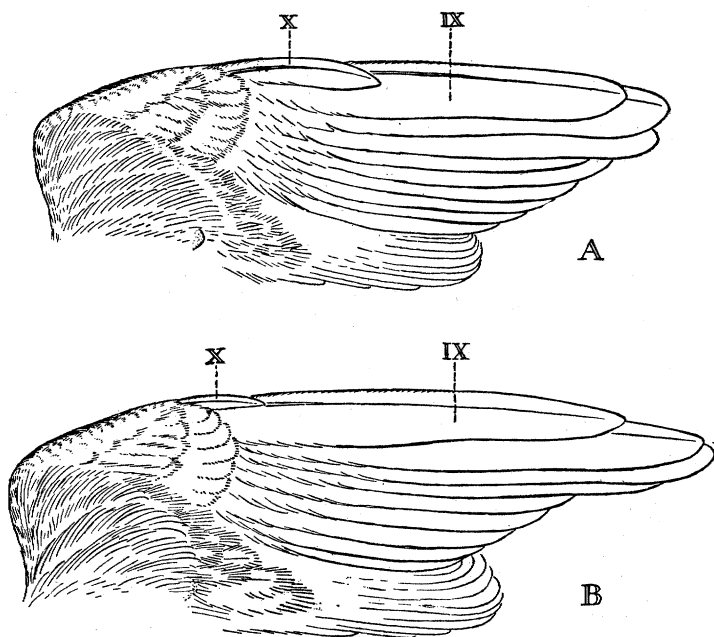


Fig. 3. *Sphyrapicus v. varius*. Wing of (A) young (B) adult from below showing large size of the 10th (outermost) primary (X), in the juvenal plumage $\times \frac{3}{4}$

of arrested development. Among the Sapsuckers the post-juvenal molt of the primaries takes place very early, as in most other young Woodpeckers, but the juvenal body plumage is retained for an unusually long period, much of it until the following spring, as in the Red-headed Woodpecker.

Still another exception was disclosed by *Leuconerpes candidus*, a South American form apparently allied to *Melanerpes*. The

condition of the inner primaries, when the wings of the young bird are almost full-grown, is essentially the same as in *Sphyrapicus*, with no loss of length in either first or second primaries. The first is a little narrower than in the adult condition, but that is all.

A third genus of woodpeckers showing no shortening of the juvenal primaries is represented by Lewis's Woodpecker. Even the innermost grows out to adult proportions, without any narrowing.

Toward the end of my search one Neotropical species was studied which bridges the gap, it appears, between reduction of the first primary and its full development, in the young. *Chrysoptilos melanolaimus*, of Bolivia, shows a first primary somewhat longer than that of *Mesopicos goertae*, yet not of full adult proportions.

The young of thirty species of woodpeckers have now been examined, illustrating all the main groups of the family. These investigations may be carried much further by anyone who possesses suitable examples of very young woodpeckers, whether alive, or as spirit-specimens, or skins. In the last case the wings can be relaxed by surrounding them for a day or two with wet cotton, after which the carpal joint is gently manipulated until the wing can be opened, and the quills examined not only with ease but without injury to the specimen.

It was in this manner that I was obliged to secure a large part of my data, and of the material for the accompanying figures. The gap in these drawings between the primaries and secondaries has been somewhat accentuated, by pushing back the latter, so as to show clearly the feathers under discussion. And for the same reason, in all views from above, the lower coverts, since they show no unusual features, have been ignored. A more exact and detailed statement of facts may here be added for future investigators.

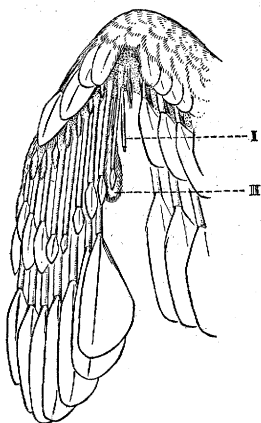
Ceophloeus lineatus similis (Lesson)

Fig. 4 C is taken from a rather young nestling, A. M. N. H., No. 81336, Xicotencatl, Tamaulipas, Mexico. All the longer primaries are still growing; length of wing 111 mm., whereas the adult wing measures 185 mm. The two reduced inner primaries have already reached their

full development, I measuring 35 mm. (adult size 123 mm.), and II, length 52 mm. (adult length 130 mm.).

Dryobates major pinetorum (Brehm).

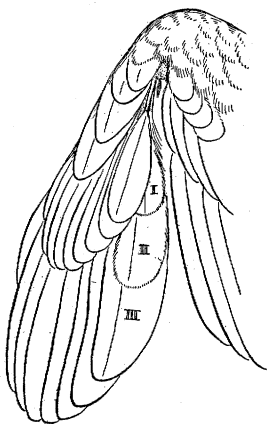
Fig. 5 C shows the wing of a nestling (♀ ?) from Dept. Cote-d'Or,



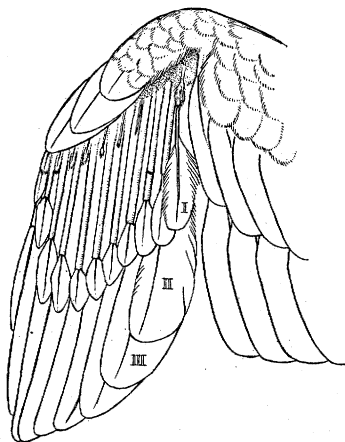
Balanosphyra formicivora aculeata



Campethera nivosa herberti



Ceophloeus lineatus similis



Colaptes auratus luteus

Fig. 4. Wings of nestling woodpeckers from above $\times \frac{3}{4}$.

France, A. M. N. H., No. 150932. Long primaries still sheathed at bases, length of wing 98 mm. (ad. length 130 mm.). No. I still entirely enclosed

in sheath, evidently not full-grown, measuring but 13 mm. (ad. l. 81 mm.); but No. II is fully grown, only 35 mm. long (ad. l. 86 mm.).

Dryobates villosus villosus (Linnaeus).

A rather large nestling examined, from Mastic, N. Y., July 8, 1916, coll. J. Dwight, No. 44165. Length of wing 80 mm. (ad. l. 81 mm.). Primaries I and II have attained full size, I measuring 17 mm. (ad. l. 81 mm.), II only 24 mm. (ad. l. 83).

Dryobates pubescens medianus (Swainson).

Fig. 5 B from nestling (♀), Washington Co., Maine, A. M. N. H., No. 113788, June 14, 1878. Length of wing only 71.5 mm. (ad. l. 94 mm.). All primaries still have sheaths except II and X. No. II, although full-grown, is only 22 mm. long (ad. l. 63 mm.), but has much the same pattern of color as the tip of No. III. No. I in both wings is in the sheath and very short, protruding only 3.5 mm.

This little stub might have been taken for the juvenal first primary, had I not found, on opening out the right wing, that the juvenal quill had just been shed, and was lying loose between the neighboring feathers. It measured 18 mm. in total length, but of this some 3 mm. would have been buried in the wing. There are thus two juvenal primaries of reduced size, as in *D. villosus* and *D. major*.

Xenopicus albolarvatus albolarvatus (Cassin).

Two young birds, male and female, from El Dorado Co., California, A. M. N. H. Nos. 87314, 87322, about ready to leave the nest, having wings of 104 and 97 mm. respectively (ad. l. 127). In both cases all the primaries had sheaths at the base except No. II. This feather was of reduced size, fully grown, but only 44 and 39 mm. long (ad. l. 80 mm.). No. I in both cases was still very small, entirely sheathed, 19 and 10 mm. long; these were undoubtedly the first winter feathers coming in, after the shedding of the small juvenal quills.

Colaptes auratus luteus Bangs.

Fig. 4 D was drawn from a young nestling, taken in the vicinity of New York. Greater primary-coverts, as well as most of the primaries, are still in the sheath, but Nos. I and II are fully developed, both being dwarfed. No. I has been raised above its covert.

Measurements from another young bird, Bay Shore, N. Y., June 29, 1909, A. M. N. H., No. 103896, are as follows: Wing, 101 mm. (ad. l. 156 mm.); juvenal primary No. I, 26 mm. (ad. l. 102 mm.); juvenal primary No. II, 40 mm. (ad. l. 107 mm.).

Picus viridis viridis Linnaeus.

Fig. 2 B, of a young female from Renthendorf, Saxony, A. M. N. H., No. 571. Wing not quite fully grown, length 120 mm. (ad. l. 160). The

two inner primaries fully developed, but conspicuously shortened; No. I measuring 38 mm. (ad. l. 102), No. II, 52 mm. (ad. l. 106 mm.). No. I has been raised above its covert so as to bring it into view.

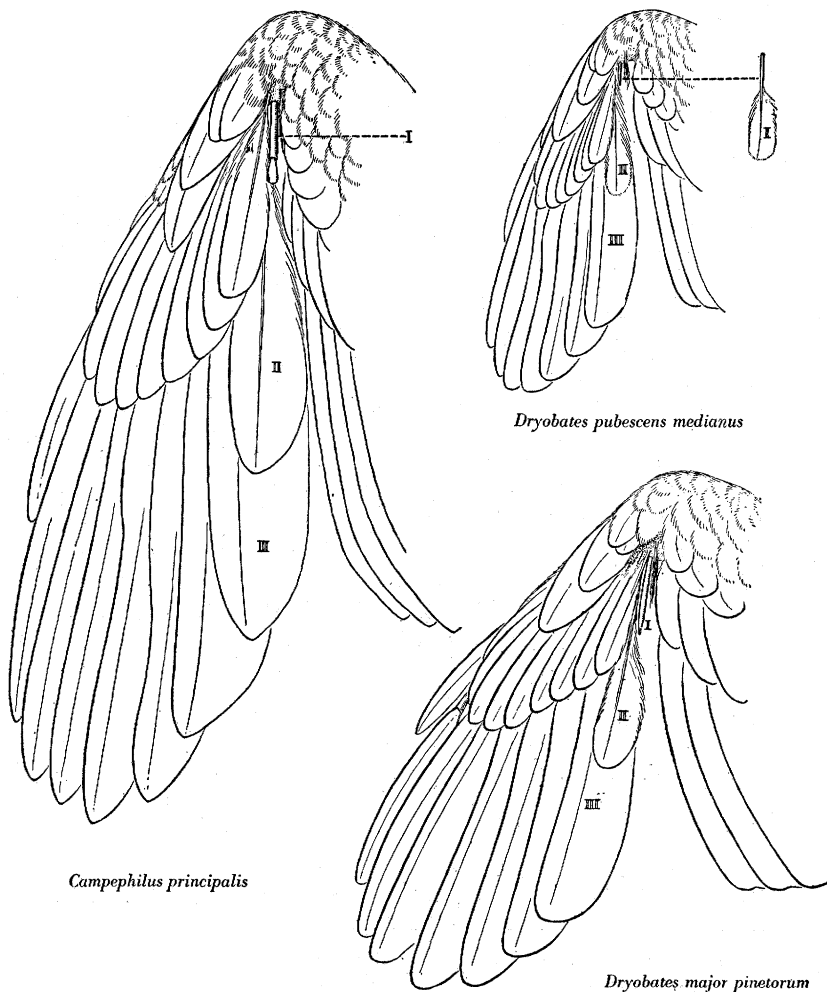


Fig. 5. Wings of nestling woodpeckers from above (A) $\times \frac{1}{2}$, (B. & C.) $\times \frac{3}{4}$.

Balanosphyra formicivora aculeata (Mearns).

Fig. 4 A is from a half-grown nestling (♀), Pinal Co., Arizona, July

30, 1884, A. M. N. H., No. 29464. The length of wing is only 72 mm., as against 139 mm. for the adult. There are clearly two dwarf primaries, for although No. I is still entirely enclosed in the sheath, No. II has attained its full growth, with calamus at base, measuring only 18 mm. in length. The second primary in an adult is 85 mm. long.

Campephilus principalis (Linnaeus).

Fig. 5A was drawn from a young ♀, with wings nearly full-grown, from Old Town, Florida, Apr. 15, 1892. Wm. Brewster Coll. No. 42972. Length of wing 210 mm. (ad. l. 254).

All the primaries still have sheaths except Nos. II, III, and X. There are two reduced inner primaries, perhaps even three, for No. III, fully developed, measures only 131 mm. (ad. l. 170). No. II is markedly shortened, 91 mm. long, whereas the same feather in an adult female measures 155 mm. No. I is just coming in, measures only 19 mm., and is almost entirely covered by its sheath. In view of its late appearance it seems doubtful whether this is the juvenal feather.

In any event it is clear that there must be a marked reduction of the two innermost primaries during nestling life. It appears to be very probable that a slight reduction of No. III is of common occurrence in species where I and II are greatly abbreviated. This is not always easy to determine, for at the age where the shortest primaries are best examined, No. III is apt not to be fully grown, and thus difficult to compare with the adult size.

Campephilus pollens pollens (Bonaparte).

A young female from La Florida, Colombia, July 11, 1911, A. M. N. H., No. 109580, has the wing fully grown, 174 mm., and all the primaries out of the sheath except No. I, which is just growing in, and measures 48 mm. This may or may not indicate that there was a small first primary at an earlier stage, but it does show that primary II was never reduced.¹

Another specimen of the same sex (♀), Cocal, Colombia, June 10, 1911, A. M. N. H., No. 109586, must be a little older. Primary I has attained its full length of 126 mm. and No. II is just coming in, showing that this species undergoes the usual post-juvenal molt.

Campephilus malherbei Gray.

A young male, from Noanamá, Colombia, Dec. 31, 1911, A. M. N. H.

¹ The American Museum has since received a younger specimen of *C. pollens*, apparently a male, from Cauca, Colombia, which shows the first juvenal primary in place. Its wing measures 161 mm. (ad. l. 174), and the longest primaries are practically complete. There is considerable reduction of the first primary, for it is 34 mm. shorter than the adjoining first secondary, and although fully grown, measures but 96 mm. as compared with 135 in an adult (a shortening of nearly one third), the second juvenal primary is only very slightly reduced, 113 mm. (ad. l. 140) and the third primary hardly at all.

No. 111840 has all the primaries full grown except I. Length of wing, 170 mm. Primary II of the juvenal plumage is not reduced in size; it would appear that the primary I now growing in (60 mm. long) is that of the "first winter" plumage. This assumption seems justified, because the first primary of the juvenal plumage is generally completely grown before the longer quills of the same series. Whether the juvenal first primary is reduced or not cannot be demonstrated.

Campephilus haematogaster (Tschudi).

A young female, from Zamora, Ecuador, Nov. 1, 1913, A. M. N. H., No. 129623, has its wings full grown (length 185 mm.), but primary I, though well grown, still retains a basal sheath, and is certainly the "first winter" quill. What the first juvenal quill was like we cannot say, but certainly No. II of the juvenal series is not reduced.

Melanerpes erythrocephalus (Linnaeus).

Three young specimens were examined, with wings so short that they must have been taken from the nest. In each case primary No. I was small, and in the sheath, but we can be almost sure it is not the juvenal quill.

The youngest in the American Museum, No. 61231, Custer Co., South Dakota, July 10, 1893, has the wing about 108 mm. (ad. l. 140 mm.). None of its primaries except the outermost (X) is full-grown, all the others have sheaths at the base, and No. II is not appreciably reduced, already 70 mm. long. Yet No. I is still only 5 mm. long, entirely enclosed in a sheath. Conditions are exactly the same in both wings. There is a great probability that the juvenal first primary has already been shed, but in no other species examined save *Centurus carolinus* and *Dryobates pubescens* has this been seen to take place so early.

Two young in Dr. Dwight's collection, with wings of 97 and 104 mm. in length, likewise show, the first primaries in their sheaths, 12 and 18 mm. long. (See Fig. 6B.)

Another young bird in the American Museum (Aug. 20) has the renewed first primary, presumably of the "first winter" plumage, already growing in. Other young taken in September show that primaries II to X are not molted at once, since I can be distinguished by its fresh black color. The post-juvenal molt of the wing-quills, in this species, takes place only toward December, so there is no close sequence between the molt of the first primary and of the others.

Centurus carolinus (Linnaeus).

Two young birds (♂), with longest primaries not quite full-grown, taken at Seven Oaks, Fla., May 20 and 22, 1912, coll. J. Dwight, Nos. 32099, 32100. In both cases the length of wing was 110 mm. (ad. l. 131 mm.). Primaries II and III were full-grown, and about of adult length,

but in both birds I was a small feather, 9 and 17 mm. long, entirely enclosed in the sheath. This is exactly like the condition in *Melanerpes erythrocephalus*, and I was unable to say whether or not the juvenal feather has already been shed until I examined a much younger bird, a female, about one-half grown, in the Museum of Comparative Zoology, No. 43447. Its wing measured 62.5 mm., and all the primaries were still sheathed at their base, even No. I. The latter was therefore not quite fully grown, but measured 24 mm., and was of soft texture, and much narrowed, only 4.5 mm. wide at its broadest part. Here then was the reduced juvenal primary we sought. No. II showed no sign either of narrowing or of shortening.

Centurus striatus (Müller).

A young female from Sanchez, Santo Domingo, March 3, 1907, A. M. N. H. No. 102072, had the wing 110 mm. long (ad. l. 117 mm.), and yet had not been long out of the nest. The innermost primary is just coming in, and already 66.5 mm. long, while the second measures 77 mm. There is no reduction of No. II; but it seems practically certain that No. I is now the first-winter feather, its juvenal predecessor being early lost, as in *Centurus carolinus*.

Hypoxanthus rivolii brevirostris Tacz.

One young bird, about two-thirds grown, from Southern Ecuador, in A. M. N. H. Its wing measures 93 mm. (ad. l. 132 mm.); all primaries are still in the sheath except No. I which is full grown, but only 38 mm. long, whereas No. II has already reached a length of 66 mm. and is still growing. The latter is clearly not reduced in size.

Campethera permista (Reichenow).

Fig. 6D from a nestling (♂), Medje, Ituri District, Belgian Congo A. M. N. H. No. 159466. All the longer primaries still have sheaths at the base; length of wing 80 mm. (ad. l. 96 mm.). Primary II not shortened but No. I extremely reduced, its full length only 18 mm. (ad. l. 71 mm.). Yet the greater upper covert of No. I is of normal size.

Campethera nivosa herberti (Alexander).

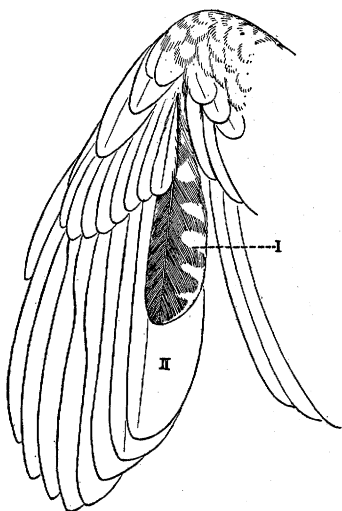
Fig. 4B taken from nestling (♀). Medje, Belgian Congo, A. M. N. H. No. 159500. Larger primaries still growing, length of wing 66 mm. (ad. l. 83 mm.). The first primary, which has reached its full length, is the only one of reduced size; it measures 25 mm. (ad. l. 63 mm.).

Chrysopicos punctatus balius* (Heuglin).

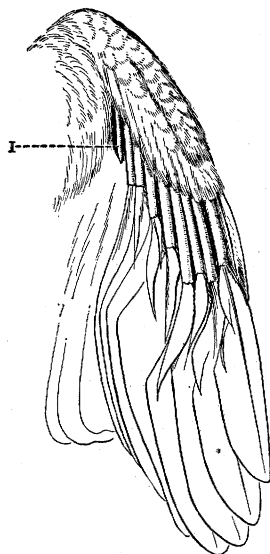
Fig. 6C is drawn from a nestling in spirit, taken at Faradje, Upper Uele District, Belgian Congo. Length of wing, 78 mm. (ad. l. 107 mm.). Second primary not appreciably shortened, but first only 27 mm. long, though fully grown (ad. l. 74 mm.).

* This genus is recognized upon the advice of Mr. W. DeW. Miller.

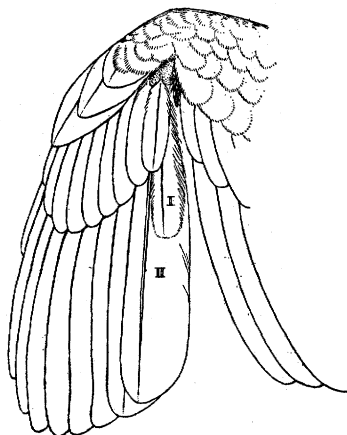
The same reduction of the innermost primary is seen in every one of a series of six nestlings of both sexes, the greatest length attained being 35 mm., or less than one-half the adult size.



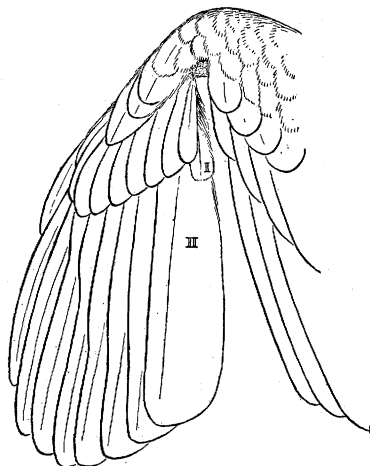
Mesopicos goetae centralis



Melanerpes erythrocephalus
(ventral side)



Chrysopicos punctatus balius



Campethera permista

Fig. 6. Wings of nestling woodpeckers. $\times \frac{3}{4}$.

It will be seen from the drawing of this species that the carpal remex is completely wanting, as it is also in *Campethera permista*, *C. nivosa herberti*, and *Leuconerpes candidus*. A vestigial, downy carpal remex is present, however, in *Dendropicos poecilolaemus*, as it is in most other Woodpeckers, being shown in several of the drawings, viz. of *Picus viridis viridis*, *Colaptes auratus luteus*, *Dryobates major pinetorum*, *Ceophloeus lineatus similis*, and *Balanosphyra formicivora aculeata*.

Dendropicos poecilolaemus Reichenow.

A fully fledged young female, from Aba, Upper Uele District, Belgian Congo, A. M. N. H. No. 159512, had wings measuring 74 mm. (ad. l. 83 mm.). Only the first primary was dwarfed, measuring 20.5 mm. (ad. l. 60 mm.).

Its color pattern is seen to be distinctly unlike that of an adult feather (Fig. 1); and it may be said that in general, the greater the reduction the more apt is there to be a difference of pattern.

Meiglyptes grammithorax (Malherbe).

A young bird from Borneo, U. S. Nat. Mus., No. 182835, is nearly full grown, wing 77 mm. (adult length 90 mm.). Only primaries VII and VIII still have traces of sheaths at their base. No. I alone is reduced, it is narrow and just 30 mm. long, in the adult it would measure 65 mm.

Xiphidiopicus percussus percussus (Temminck).

A rather young nestling (♂) from Cuba, U. S. Nat. Mus. No. 172584, has a wing of only 65 mm. (ad. l. 120 mm.). All the primaries have basal sheaths, including even No. I, which is, however, nearing its full growth, and still only 29 mm. long, being distinctly narrowed, besides. (ad. l. 90 mm.). No. II shows no reduction, either in length or in width.

Tiga javanensis (Ljung).

A large nestling from Depok, Java, U. S. Nat. Mus. No. 219317, has the wing 106 mm. long (adult length = 138 mm.). All its primaries have sheaths at the bases except No. I, which is fully grown, but rather narrower than II, and only 47 mm. long (ad. l. 97 mm.). There is evidently no reduction of No. II, which is already 67 mm. in length.

Mesopicos goertae centralis Reichenow.

A nestling (♂) from Faradje, Belgian Congo, Am. Mus. Nat. Hist. No. 159530, has the wings 90 mm. (ad. l. 110 mm.). All its primaries are still growing out of sheaths except No. I, which has completed its development, and measures 43 mm. (ad. l. 75 mm.). Its color pattern is very similar to that of II and other inner primaries. (See Fig. 6 A.)

Here there is only moderate reduction of but one primary, so the char-

acter is intermediate between conditions in *Chrysopicos* and in a form like *Leuconerpes* showing no reduction.

Chrysophilus melanolaimus (Malherbe).

A rather large nestling was examined from Pulque, Prov. Sucre, Bolivia, Am. Mus. Nat. Hist. No. 139154. All primaries still in the sheath, including No. I, which though narrower than No. II and evidently somewhat stunted, is already 67 mm. in length (adult length = 107 mm.). There is thus only a slight reduction of a single inner primary, and a condition intermediate between that in *Mesopicos goertae*, for example, and in *Leuconerpes candidus*. This is confirmed by a second specimen from the same brood.

Leuconerpes candidus (Otto).

A well-developed nestling, from Matto Grosso, Brazil, Am. Mus. Nat. Hist., No. 34293, shows very clearly that there is no reduction in length of the inner primaries. Only primary X is full grown; the others have still a slight basal sheath, yet I and II have nearly the same relative proportions as in the adult. Length of wing 131 mm. (adult length 162 mm.); primary I, 79 mm. long (adult length 94 mm.); primary II, 86 mm. (adult length 100 mm.). The inner primaries are somewhat narrower than in the adult.

Asyndesmus lewisi Riley.

A young female from La Plata Co., Colorado, July 8, 1892, in A. M. N. H. has the wing 150 mm. long (ad. l. 169 mm.). All the primaries except X still have sheaths at the base, but there is no shortening or narrowing of any of the inner primaries. No. I already measures 92 mm. and is still growing.

Another young bird from British Columbia has the wing full grown, 164 mm., but there is no sign either of reduction of the inner primaries or of a beginning of post-juvenal molt. So the juvenal inner primaries are of full size as in the Sapsuckers, to which Lewis's Woodpecker is by no means closely related.

Sphyrapicus varius varius Linnaeus.

A nestling from Delaware Co., N. Y., Am. Mus. Nat. Hist., No. 65251, with wing already 88 mm. long (adult length 124 mm.) has all its primaries except X still in the sheath, yet I and II bear about the same relation to their fellows as they would in the adult. No. I is already 58 mm. long (adult length 70 mm.).

In this specimen, as well as in nestlings of *S. v. nuchalis* and *S. thyroideus*, there seems to be something peculiar about the growing base of primary VI of the juvenal series. Its tube or sheath is noticeably slenderer than those adjoining on each side, and appears to break away more quickly, yet the fully developed feather shows no resultant peculiarity.

This is the single quill that grows on the phalanx of the third digit of the manus. No such peculiarity was noted in any other woodpecker, not even *Leuconerpes*.

Sphyrapicus varius nuchalis Baird.

A nestling from Boulder Co., Col., U. S. Nat. Mus., No. 84310, with primaries still in the sheath, shows large first and second primaries.

Sphyrapicus ruber ruber (Gmelin).

A nestling (♂) from Fort Klamath, Ore., July 14, U. S. Nat. Mus. No. 558, shows no reduction of primaries I and II.

Sphyrapicus thyroideus (Cassin).

Two nestlings from Colorado (♂ and ♀), U. S. Nat. Mus., Nos. 84321 and 84322 have wings 78 and 84 mm. long (adult length 136 mm.) respectively. Both have primary I well developed, and about as long as No. II, agreeing thus with the young of *S. varius*.

PROBABLE SIGNIFICANCE.

Having demonstrated the frequency and diversity of this unusual character among nestling woodpeckers, let us consider its possible interpretation. Does it repeat any previous stage in evolutionary development? Probably not. It seems beyond question that the woodpeckers have originated from a line of descent more like the barbets than any other living group, and the Capitonidae show no reduction of the inner primaries either in the adult or in the young, certainly not in the several genera, *Hellobucco*, *Tricholaema*, *Buccanodon*, and *Lybius*, which I have carefully examined. Furthermore, reduction in the size or number of primaries, in all the higher groups of birds, seems to have taken place at the distal, not the proximal end of the primary series.

A clear case of "recapitulation," for example, may be seen in the 10th (outermost) primary of many Picidae, which is conspicuously longer in the juvenal plumage than it is in the adult. Perhaps the best illustration—pointed out to me by Mr. W. DeW. Miller—is offered by the sapsuckers (*Sphyrapicus*), where the wing-tip is exceptionally long and pointed, and the 10th primary of the adult unusually small. In the first plumage the corresponding feather is approximately 66 per cent. longer, as well as much wider, than in the parents' wing. (See fig. 3.) This indi-

cates that the quill in question was better developed in the ancestral forms, and supports the prevailing view that the number of primaries, and the size of the outer one, have undergone reduction in the Passeres, Pici, and other specialized groups of birds.

So far as we know, then, or can surmise, the diminished size of the young woodpeckers' inner primaries does not represent any earlier stage in the ancestral history of this extremely specialized family. We are more inclined to look upon this condition as fitting the young woodpecker for some nest-dwelling exigency, and comparable, in a way, to the rasp-like heel-pad of young barbets and toucans, which likewise disappears before adult life. But why, it might be asked, do not other young birds reared in cavities of trees possess this same character? I can only answer that the Picidae exhibit a number of striking adaptations to a life spent climbing upon the bark of trees, such as their chisel beak, resistant skull, barbed, extensile tongue, and stiffened, pointed rectrices, which are wanting, in part at least, among all the other groups of birds that have adopted similar modes of life, namely the Dendrocolaptidae, Sittidae, and Certhiidae. This is only one more case where the Picidae lead.

For a while we were unable to suggest any need or advantage for a gap in the wing-feathering at the carpus, especially as the first secondary is in no wise affected by this circumstance.

The shortening of these primaries is of course effected by the premature arresting of the growth of the feather, the dwindling of the barbs and the formation of a normal calamus or barrel. This is exactly the same process that determines the length of any ordinary contour-feather, and what the immediate causes are seems not very readily explained. They may be concerned with blood supply, and histological study of the normal feather papilla as compared with those of powder-down feathers, or of the plumes of Japanese long-tailed fowls, might reveal something. This is a matter of considerable interest, in view of the extreme accuracy with which it is timed, so as to allow of little variability in a primary-formula, for example, or of wing-length which is a universally accepted standard for any given species, and which usually gives a real scientific basis for the so-called "millimeter race."

In this particular case of the young woodpecker, it might be ascribed to imperfect nutrition of this region of the wing, but it is only one or two quills that are affected, whereas the adjoining coverts would be expected to share in this starvation. It was felt that such an exceptional condition would hardly have been perpetuated unless some selective value could be attributed to it.

A hypothesis offered by Mr. J. T. Nichols, when he heard of these facts, is of decided interest. A gap in the wing, he argued, would allow the young birds with less difficulty to stick up their heads to be fed, in the cramped quarters of the woodpecker nest.

To be sure, should such a condition arise, it would not immediately benefit the bird possessing it so much as its nestmates, consequently this might make an explanation less plausible on the basis of natural selection. On the other hand were the parents bearers of a hereditary factor that would bring out the wing character in all their young, we might assume that all the nestlings would benefit by a more equitable share of the food, thus assuring a more numerous progeny.

Whatever the explanation, Mr. Nichols pointed out to me that there is already direct photographic evidence supporting this theory in a motion-picture taken by Dr. T. S. Roberts and Mr. Jenness Richardson of the University of Minnesota, which was exhibited at the meeting of the American Ornithologists' Union in 1916. This film shows the young flickers being fed at the entrance to their nest. The old bird is clinging to the bark outside; two young birds are leaning well out of the opening, begging for food. One of them has a wing out of the hole, and very much in the way of its companion's open beak. The difficulty is speedily overcome by nestling No. 2, which pokes its head and neck through the wing just between the primaries and secondaries, right at the gap under discussion; and they hold this position for some little time. This is clearly shown by Plate XIX, which is taken from this instructive and timely film.

Why young sapsuckers should differ from the majority of young Picidae is a question I cannot answer for the present, but gladly leave to the curiosity of field ornithologists. They cannot fail to find here an inviting point for elucidation; indeed the young of any of the woodpeckers will be well worth careful observation.



YOUNG FLICKERS AT NEST HOLE: HEAD OF ONE PROJECTING THROUGH
WING OF ANOTHER.

From photos supplied by Zool. Mus., Univ. of Minn.

The systematic ornithologist, on the other hand, will be anxious to see what use can be made of this new character in arranging the lesser groups within the family of woodpeckers. It is not common to the whole of the Picidae, and might lead us therefore to segregate the sapsuckers, as Dr. Coues once did, in a separate

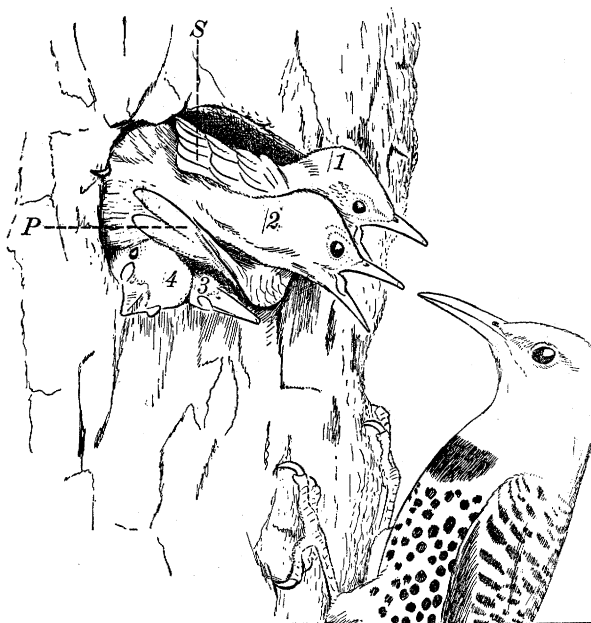


Fig. 7. Key to plate XIX. fig 2: P. primaries, S. secondaries of young bird No. 1.

subfamily. Yet in almost all their external characters the species of *Sphyrapicus* are close to *Dryobates*, with which they have recently been placed by Mr. Ridgway in the same super-generic association.* Moreover there are other genera, like *Asyndesmus*, *Leuconerpes* and *Chrysoptilus*, showing no very small inner primaries, and yet utterly unlike *Sphyrapicus* in other structural characteristics. It would seem then that large-sized inner primaries, among young woodpeckers, rather than constituting a primitive heritage, were re-acquired, secondarily and perhaps

* Birds of North and Middle America, VI, 1914, p. 10.

independently, by members of several different groups. This would detract greatly from the usefulness of such a feature for purposes of classification.

It is possible, nevertheless, that the number of primaries reduced, whether two or only one, may indicate an affinity between various species or even genera. At all events, in spite of the very evident adaptive nature of such a character, it is one additional point to be considered in the weighing of relationships.

At least two very different species of *Campethera*, and one each of *Chrysopicos*, *Dendropicos*, *Mesopicos*, *Tiga*, *Meiglyptes*, one of *Hypoxanthus* and *Xiphidiopicus* agree in having but a single inner primary reduced; whereas the Green, the Downy, the Hairy, the Great Spotted, the White-headed, and Mearns' Woodpeckers, the Flicker, and a Mexican Pileated Woodpecker agree in the presence of two such stunted feathers. Yet the Red-headed and Red-bellied Woodpeckers, which are often considered as congeneric with Mearns' Woodpecker, are found to have but a single small feather, at most. And so two other genera, *Asyndesmus* and *Leuconerpes*, likewise believed to be nearly related to *Melanerpes*, agree with *Sphyrapicus* in the well-developed first and second primaries of their young.

It is probable that within the *Dryocopus* group some of the genera will show one small primary, others two, as in *Ceophloeus lineatus*. The same thing has already been established for the "Ivory-bill" group (Campephileae of Ridgway) where *Campephilus principalis* shows two, and three other species of doubtful generic distinctness not more than one.

I may state that Mr. W. DeW. Miller, who has recently been making a very thorough investigation of the supergeneric groups of woodpeckers, and has given me every assistance in the preparation of this paper, cannot find any correlation between the present character and the important structural features which mark them otherwise. He is of the opinion that the piculets form a distinct family from the typical woodpeckers, and thus far we have been unable to discover in the Picumnidae any evidence

either of a post-juvenal molt or of juvenile reduction of an inner primary.

The majority of the species which we have shown to possess but a single dwarfed primary will be seen to have a more or less tropical distribution, while those with two are in general of more northern climes. Whether this is a general rule we cannot say as yet; in any case it appears to possess little significance, since *Sphyrapicus*, with no reduction, is a distinctly northern group, at least with regard to its breeding range.

SUMMARY.

In many different genera of woodpeckers, the first, or the first and second (inner) primaries of the juvenal plumage attain but a fraction of the normal size in the adult. They are, however, quickly replaced, at the very beginning of the early post-juvenal molt so characteristic of the Picidae, by quills not differing greatly in length from the adjacent primaries and secondaries. Even where the post-juvenal molt is delayed, the reduced primary is rapidly shed and renewed. No difference could be discovered between the sexes with regard to the size or molt of these feathers. The genera *Sphyrapicus*, *Asyndesmus*, and *Leuconerpes* and possibly others, offer an exception to the rule, having no dwarfed inner primaries. The condition of these feathers of the nestlings, in all species thus far examined, is indicated in the following table.

Reduction of Inner Primaries in Species studied thus far.

Shortening of two	{	Ceophloeus lineatus
		Dryobates major
		Dryobates villosus
		Dryobates pubescens
		Xenopicus albolarvatus
		Colaptes auratus
		Picus viridis
		Balanosphyra formicivora
		Campephilus principalis

Shortening of one	{	Campephilus pollens
		Campephilus malherbei
		Campephilus haematogaster
		Melanerpes erythrocephalus
		Centurus carolinus
		Centurus striatus
		Hypoxanthus rivolii
		Campethera permista
		Campethera nivosa
		Chrysopicos punctatus
		Dendropicos poecilolaemus
		Meiglyptes grammithorax
Narrowing, but little shortening	{	Xiphidiopicus percussus
		Tiga javanensis
		Mesopicos goertae
No reduction	{	Chrysophilus melanolaemus
		Leuconerpes candidus
		Asyndesmus lewisi
		Sphyrapicus varius
		Sphyrapicus ruber
		Sphyrapicus thyroideus

The value of this character in revealing the affinities of the various groups within the family is very doubtful. It is probably an adaptation of some utility during early life in the limited space of the nesting hollow, perhaps as suggested by Mr. Nichols, enabling the young birds while being fed to raise their heads through one another's wings, there being indeed photographic grounds to uphold this theory in the case of young Flickers.

American Museum of Natural History, New York.

BREEDING BIRDS OF WARLAND, LINCOLN CO., MONTANA.

BY THOMAS D. BURLEIGH.

WARLAND lies on the Kootenai River and is but a small town which owes its existence to the saw mill of the Baird-Harper